Roadway Departure Safety Design

2015 TRANSPORTATION SAFETY SUMMIT

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FHWA - Office of Safety Technologies

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U.S. Department of Transportation
Federal Highway Administration

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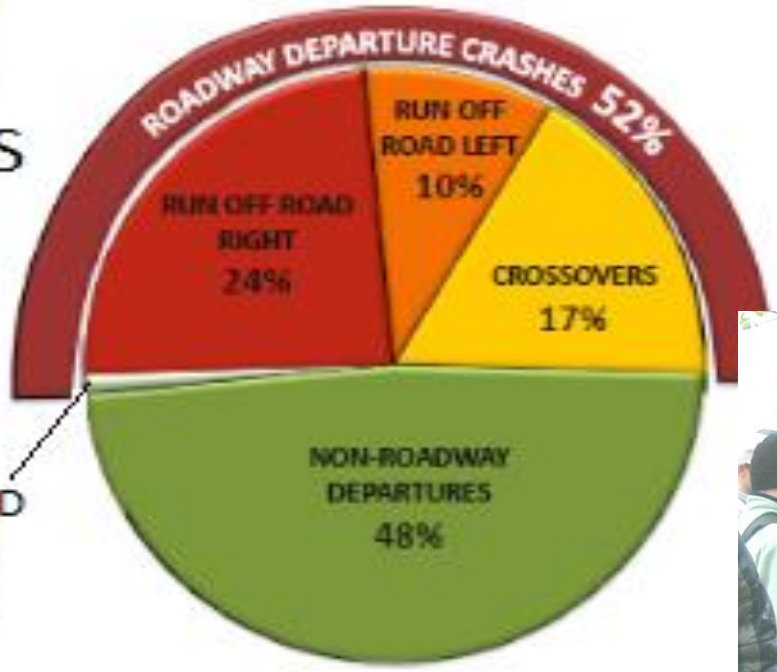
Agenda

- Keep Vehicle on the Road
  - Pavement Treatment – HFST, Shoulder treatments, Safety Edge
  - Pavement Marking and Delineation
- Remove Roadside Hazards
- Redesign Roadside Features
- Breakaway Hardware
- Addressing Intersections ain Curves
- Systemic Approach to Safety
- Q and A

Why worry about the roadway Departure? 15,000 deaths per year in the USA

34,156
FATAL
CRASHES



UNDESIGNATED
ROADWAY
DEPARTURES
1%

17,991
FATAL
ROADWAY
DEPARTURE
CRASHES

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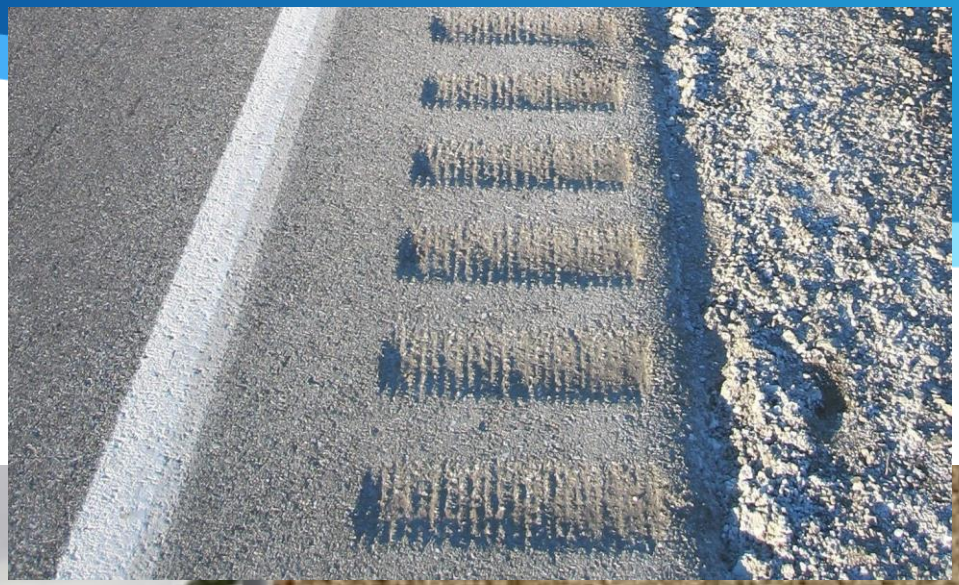
Keeping Vehicles on the Roadway

Prime Directive: Keep the vehicle on the road!



Delineation/Guidance, Pavement treatment

What is a HFST?

- **HFST are resin-based pavement surfacing overlay systems:**
  - **exceptional skid-resistant properties**
  - **retains the higher friction property for a much longer time.**
- **Commercially available**
- **Generally applied to improve spot locations where friction demand is critical.**

HFST Aggregates

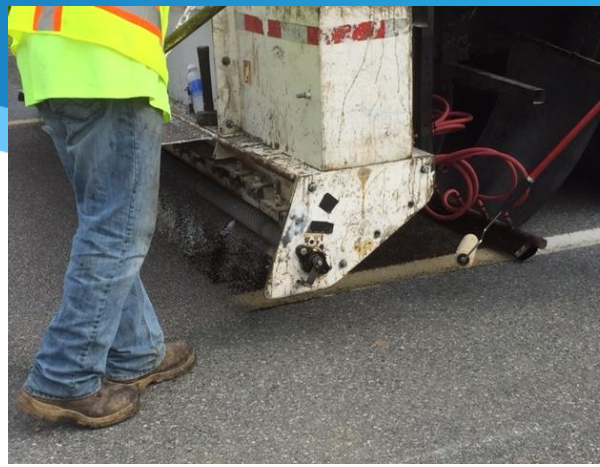
- Recommended aggregate is calcined bauxite to provide the highest resistance to polishing, but flint, granite, slags and other materials have been evaluated.
- Generally 3-4 mm maximum size

HFST Binder Materials

- Binder system (proprietary blends)
  - Bitumen-extended epoxy resins
  - Epoxy-resin
  - Polyester-resin
  - Polyurethane-resin
  - Acrylic-resin

HFST reduce crashes, injuries, and fatalities.

- ***Where Can HFST Benefit Safety?***
  - Horizontal curves and Ramps
  - Approaches to intersections
  - Down grade road sections
- ***Other benefits include:***
  - customizable to specific state and local safety needs
  - high return on investment
  - minimal impact to traffic during construction
  - negligible environmental impact



Kentucky Results

High Friction Surfaces

- **43 HFST installations on ramps and horizontal curves constructed between 7/2009 to 10/2012.**
- **Evaluation of curve projects shows a 73% overall yearly total reduction and 86% reduction in yearly wet crashes**
- **For ramp projects it shows a 78% overall yearly reduction in crashes with wet-weather crash reduction of 85%**

Figure 1: Marbled Murrelet (top) & Northern Spotted Owl (bottom)

HFST: A Cost-Effective, Lifesaving Solution for an Environmentally Sensitive Location in California

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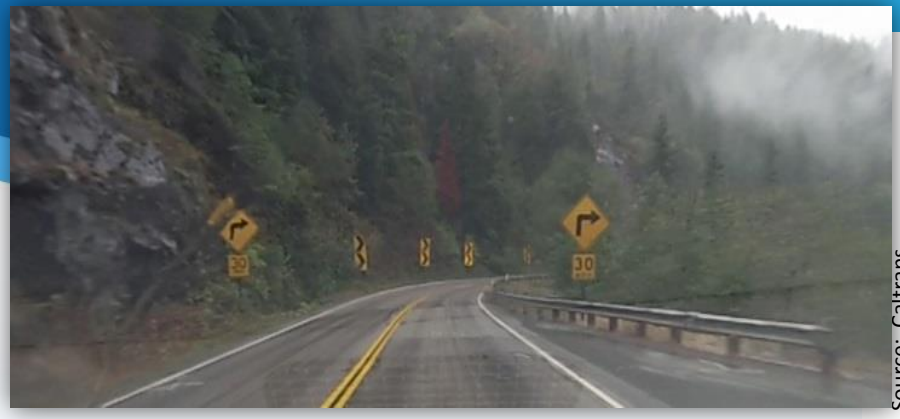
Background



SR 199 in Del Norte County

- A horizontal curve on State Route199 in Del Norte County within the Redwood National Parks' limits experienced high frequencies of wet crashes.
- Between 06 and 09, experienced 26 wet crashes & total and severe (fatal + injury) crash rates, 7.3 and 4.3 times, respectively, greater than the statewide average.
- Several low-cost safety countermeasures were tried but did not lead to the crash reductions desired.
- consider larger scale countermeasures, specifically roadway realignment which would require a lengthy environmental review and mitigation of wetland impacts.

Key Factors Effecting the Final Decision

- Realignment project would needed
  6 months acquiring environmental permits.
- Required to mitigate construction effects upon the wetlands.
- Any wetland replacement could delay the project for years as crashes continue to occur.
- Any geometric improvement incurs time restrictions (i.e., environmental windows) aimed at not disturbing wildlife.
- Detour could take longer than 8 hours, which is estimated to cost upwards of $450 million a year in economic losses.

	HFST	Curve Realignment
Environmental Review and Design Timeframe	4-6 months	2 to 5 years
Construction Duration	10 working days	> 6 months
Cost	~ $250,000 total	>$14 million
Detour	Not necessary: Treatment can be installed one lane at a time	Necessary: Roadway must be closed during construction

Selecting HFST

Source: Caltrans

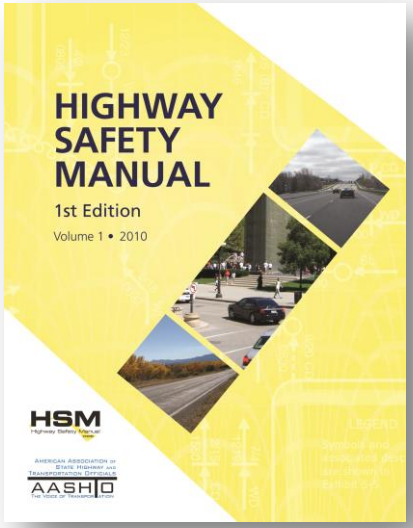
Figure 3: SR 199 HFST Application Area

- In summer 2012, Caltrans installed 850 ln.ft. of HFST at this horizontal curve on SR 199.
- Install a double layer of epoxy-resin binder w/ calcined bauxite aggregate, which filled in the surface voids from the previously installed OGAC and added protection against water penetration.
- With approximately 600 vehicles per hour (vph), only a 5 minute travel time delay during active construction.
- Caltrans is unaware of any crashes at this location since the HFST implementation.

Keeping Vehicles on the Roadway

Pavement Marking & Delineation

Edge and Centerline Markings



Edge lines

Centerlines

Table 13-39. Potential Crash Effects of Placing Edgeline and Centerline Markings (8)

Treatment	Setting (Road Type)	Traffic Volume	Crash Type (Severity)	CMF	Std. Error
Place edgeline and centerline markings	Rural (Two-lane/ Multilane undivided)	Unspecified	All types (Injury)	0.76	0.1
Base Condition: Absence of markings.					

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lives

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Application of Edge lines in Missouri

PROGRAM DETAILS

- MODOT chose to apply an edge line stripe to state-maintained roads with an Annual Average Daily Traffic (AADT) volume between 400 to 1,000 vehicles per day.
- Roads with an AADT greater than 1,000 vehicles per day were assumed to already have an edge line, while roads with an AADT less than 400 vehicles per day were assumed to only have a center line stripe (which is sufficient for a low volume road).

Application of edge line at a horizontal curve.

Program details (Continued)

- Once MODOT identified the treatment locations, they were able to move the process forward by first changing internal policy and receiving management approval.
- The next step was for individual districts to provide estimated initiation timelines and completion dates for the project. One district in particular was ambitious and completed their striping within one year.
- All Missouri districts are now required to restripe every other year but are not required to take on additional miles below the 400 vehicles per day AADT threshold.

Results

- A simple before-after analysis of the locations showed a total of 576 crashes from 2006 to 2008—105 of which involved a fatality or severe injury.
- After edge lines were added to these roadways, the two-year after data (2010-2011) showed that total crashes decreased 43 percent to 327 crashes, and fatalities or severe injuries decreased 56 percent to 46 crashes.
- A more sophisticated empirical Bayes analysis found that the addition of edge lines reduced total crashes for all crash types by 15 percent.
- Utilizing the Systemic Safety Project Selection Tool, the analysis also revealed that the treatment reduced severe crashes by 19 percent.
- MODOT has not received any negative feedback regarding the new edge lines from the general public or local agencies.

Considerations

- Recommends that agencies use a systemic approach to safety, especially with regards to edge lines.
- Since it is not feasible to stripe and maintain every road in the State, MODOT suggests treating sites with higher volumes as those roads will have a greater probability of a crash occurring.
- The improvement process should be data-driven to ensure justification of location prioritization.
- The local county agencies would benefit from installing edge lines on their roadway system, even though they lack the data to properly identify the roads that may warrant the treatment.

Are Wider Edge Lines Better?

4-inch Width

6-inch Width

CMF
CRASH MODIFICATION FACTORS CLEARINGHOUSE

Countermeasure: Install wider markings WITHOUT resurfacing

CMF	CRF(%)	Quality	Crash Type	Crash Severity	Roadway Type	Area Type
0.78	22	★★★★☆	All	Fatal,Serious injury,Minor injury	Principal Arterial Other Freeways and Expressways	Rural

Reflective Barrier Delineation

- Concrete Barrier Rail

- Metal Guardrail

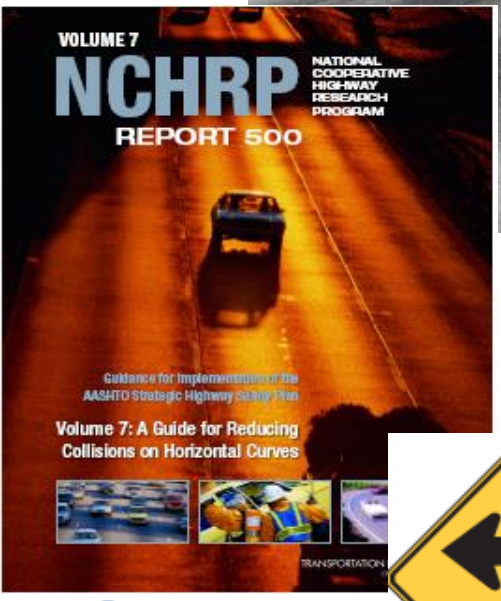
Other Longitudinal Delineation

- Delineators
- Advance Markings for curves
- Speed Reduction Markers(Optical Speed Bars)
- RPMs (Raised Pavement Markers)

Figure 12. Photo. The color of delineators must match the color of the adjacent edge line. Source: Texas Transportation Institute.

Reflective Barrier Delineation

Signs to Keep Vehicles on the Roadway



Crash Types Addressed by Signing:

- Curve Crashes
  - Includes crashes in the head-on and run-off-road (ROR) categories
- Nighttime Crashes
  - Mostly ROR crashes

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W1-8

Warning Signing for Curves

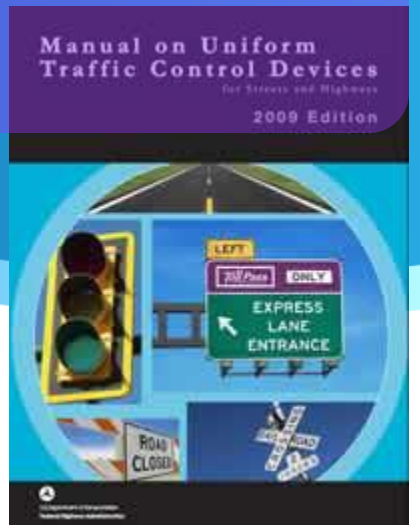
Advance Warning Signs for Curves:

CRASH MODIFICATION FACTORS CLEARINGHOUSE

Countermeasure: Advance static curve warning signs

CMF	CRF(%)	Quality	Crash Type	Crash Severity	Roadway Type	Area Type
0.7	30	★☆☆☆☆	All	Serious injury,Minor injury	Not specified	Not specified
0.92	8	★☆☆☆☆	All	Property Damage Only (PDO)	Not specified	Not specified

2009 MUTCD



Section 2C.02 Application of Warning Signs Standard:

Section 2C.06 Horizontal Alignment Warning Signs

Table 2C-5. Horizontal Alignment Sign Selection

Type of Horizontal Alignment Sign	Difference Between Speed Limit and Advisory Speed				
	5 mph	10 mph	15 mph	20 mph	25 mph or higher
Turn (W1-1), Curve (W1-2), Reverse Turn (W1-3), Reverse Curve (W1-4), Winding Road (W1-5), and Combination Horizontal Alignment/Intersection (W10-1) (see Section 2C.07 to determine which sign to use)	Recommended	Required	Required	Required	Required
Advisory Speed Plaque (W13-1P)	Recommended	Required	Required	Required	Required
Chevrons (W1-8) and/or One Direction Large Arrow (W1-6)	Optional	Recommended	Required	Required	Required
Exit Speed (W13-2) and Ramp Speed (W13-3) on exit ramp	Optional	Optional	Recommended	Required	Required

2009 MUTCD Chapter 2C :Support:

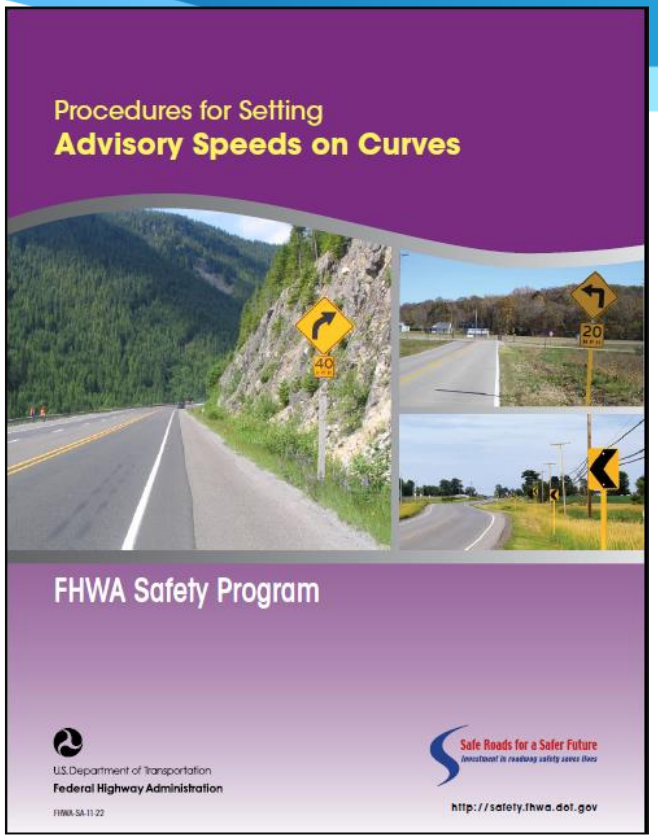
Among the established engineering practices that are appropriate for the determination of the recommended advisory speed for a horizontal curve are the following:

A. An accelerometer that provides a direct determination of side friction factors
B. A design speed equation
C. A traditional ball-bank indicator

Advisory Speed Guidance

The handbook describes:

1. guidelines for determining when an advisory speed is needed;
2. criteria for identifying the appropriate advisory speed;
3. an engineering study method for determining the advisory speed; and
4. guidelines for selecting other curve related traffic control devices.



http://safety.fhwa.dot.gov/speedmgt/ref_mats/fhwasa1122/fhwasa1122.pdf

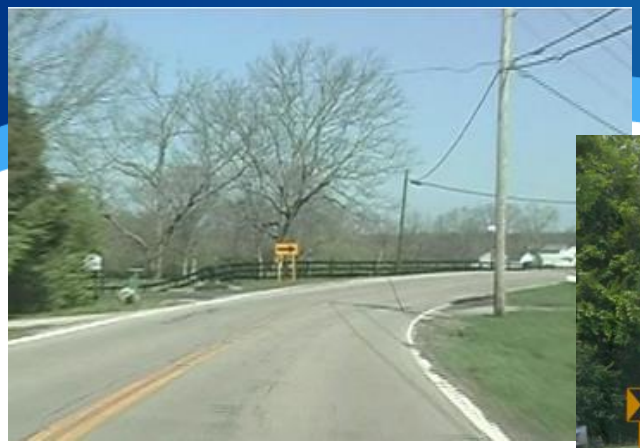
Multiple Curves

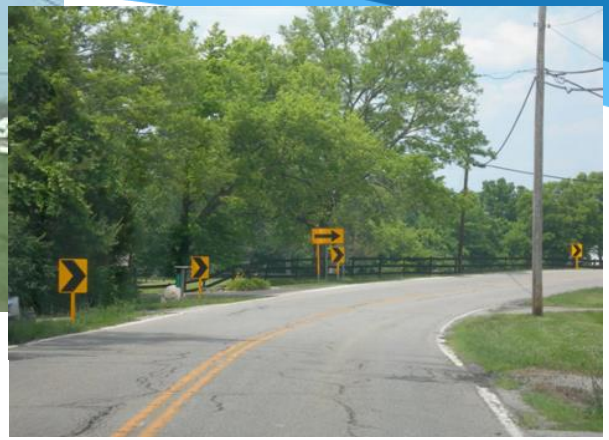
- A Winding Road (W1-5) sign may be used instead of multiple Turn (W1-1) or Curve (W1-2) signs where there
  - are three or more changes in roadway alignment each separated by a tangent distance of less than 600 feet.
  - A NEXT XX MILES (W7-3aP) Supplemental distance plaque (see Section 2C.55) may be installed below the Winding Road sign where continuous roadway curves exist for a specific distance.

Upgrading curve Signing in Ohio

- In 2010, Ohio DOT introduced a Horizontal Curve Program for state-maintained roads by focusing on upgrading and installing signage at curves.
- Select countermeasures – low-cost in all districts in Ohio .
- Ohio DOT's central office provided each district a list of curve locations ranked by crash frequency.
- Select 576 sites using a threshold of 6 or more crashes over a 5-year period on 0.3 mile segments to flag problematic locations.
- Conduct field reviews to evaluate existing conditions and countermeasures onsite, and selected the appropriate signs at the site. Funds from High Risk Rural Roads or HSIP were used.
- Additional curve sign upgrades that were developed through an FHWA Roadway Departure Plan will be systemically implemented.

Before and After Signage Improvement





A curve on a rural, two-lane road before and after signage updates through the Horizontal Curve Program.

A curve on a rural, two-lane road before and after signage updates through the Horizontal Curve Program.

Results

- Ohio DOT is in the process of analyzing the safety effectiveness of the sign upgrades, starting with the locations treated in 2010.
- received positively by the general public and local agencies alike.
- The districts noted that treating problematic curves is easy to implement when the central DOT office provides them with the necessary tools (i.e., the list of high-crash curves and sign order forms).
- Drivers are pleased that the signs provide proper guidance around curves, especially at nighttime.

Considerations

- A key aspect of the program's success is the cooperation between the DOT main office and the individual State districts.
- The central DOT office supplies the data, which allows the districts to focus time and staff on site visits and implementation of the appropriate solutions.
- When considering a similar program, agencies need to emphasize the importance of having a data-driven program.
- Crash data enables Ohio DOT to generate the crash lists and prioritize locations for Districts to address.

Enhancing Warning Signing for Curves

Oversize Background and Yellow Flashers

Oversize

Enhancing Warning Signing for Curves

Dynamic Signs

Doubled-Up

Doubled-Up & Yellow Warning Flashers

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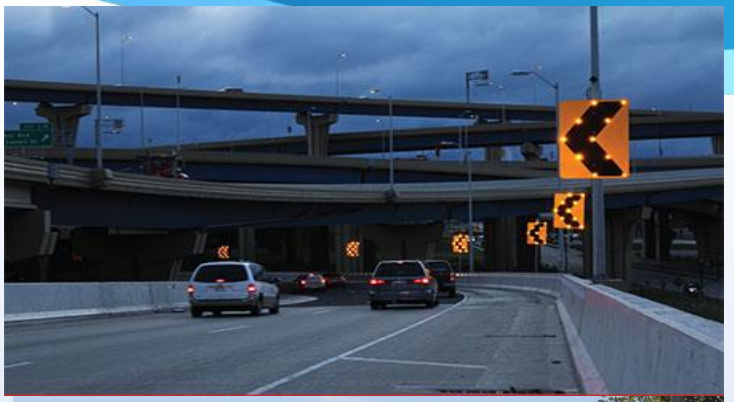
Enhancing Warning Signing for Curves

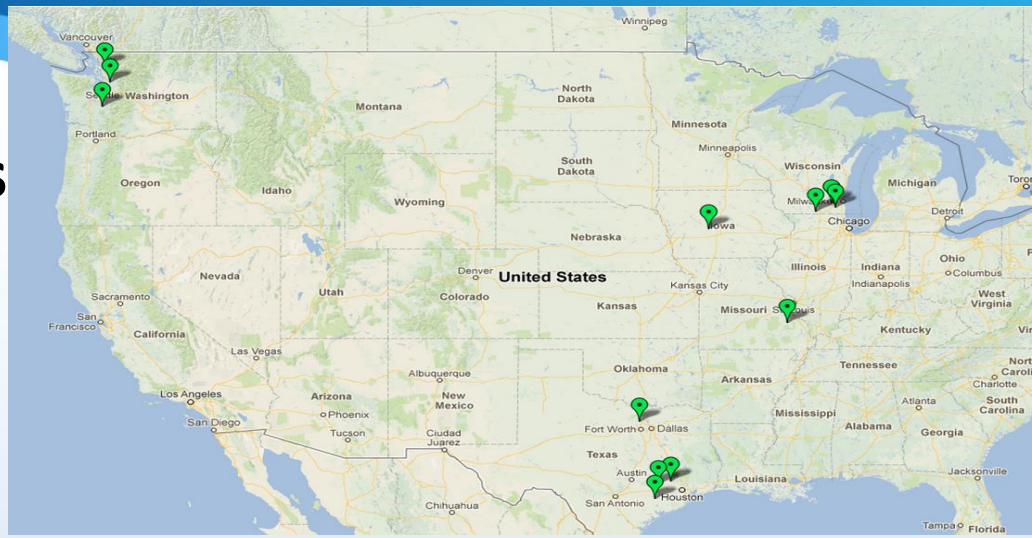
Speed Feedback Signs

Sequential Dynamic Curve Warning Systems (SDCWS)

- horizontal curve chevron signs with solar powered flashing lights embedded in the sign.
- The flashing lights can be simultaneous-flashing at the same time as the other signs
- Or there may be a pattern associated with the flashing lights-a sequence of lights moving toward or away from the driver



Research summary



- FHWA Highway For Life evaluation of effectiveness of SDCWS.
- Since only 12 SDCWS locations included in the study sample, only one manufacturer's product was selected for implementation in the evaluation to ensure consistency in system design and application.
- The TAPCO system was selected as a typical representation of SDCWS's.
- 4 states were selected for study sites.
- The study sites were identified based on a high-crash history, as well as vehicle operating speeds that exceeded the advisory (if present) or posted speed limit.

Criteria for Installation

- two-lane rural paved road with posted speed limit of 50 mph or higher and with existing chevrons.
- No railroad crossing or major access points within the curve.
- At least 10 non-animal related crashes in the previous 5 years.
- No major rehabilitation or changes in alignment in the previous 5 years and none planned in the next 2 years follow.

Findings:

- The need for solar power for proper operation of the SDCWS.
- Agencies need to pay attention to the operation of the devices to make sure they are functioning.
- Devices with solar panels can be subjected to vandalism.
- Agencies might want to experiment with speed threshold and blinking pattern settings to maximize the effectiveness of the devices.

Conclusions

- The treatment appeared to be effective in reducing speed and crashes.
- The speed analysis showed reductions in mean and 85 percentile speeds.
- The analysis also showed the reduction in the percent of vehicles exceeding the speed limit or advisory speed limit by 5, 10, 15, or 20 mph.
- The crash analysis, using a simple analysis with only two years of after data showed improvement in safety by reducing crashes.

Nighttime Driving

Retroreflectivity provides nighttime guidance

Daytime

Many cues available

Driver task relatively easy

Nighttime

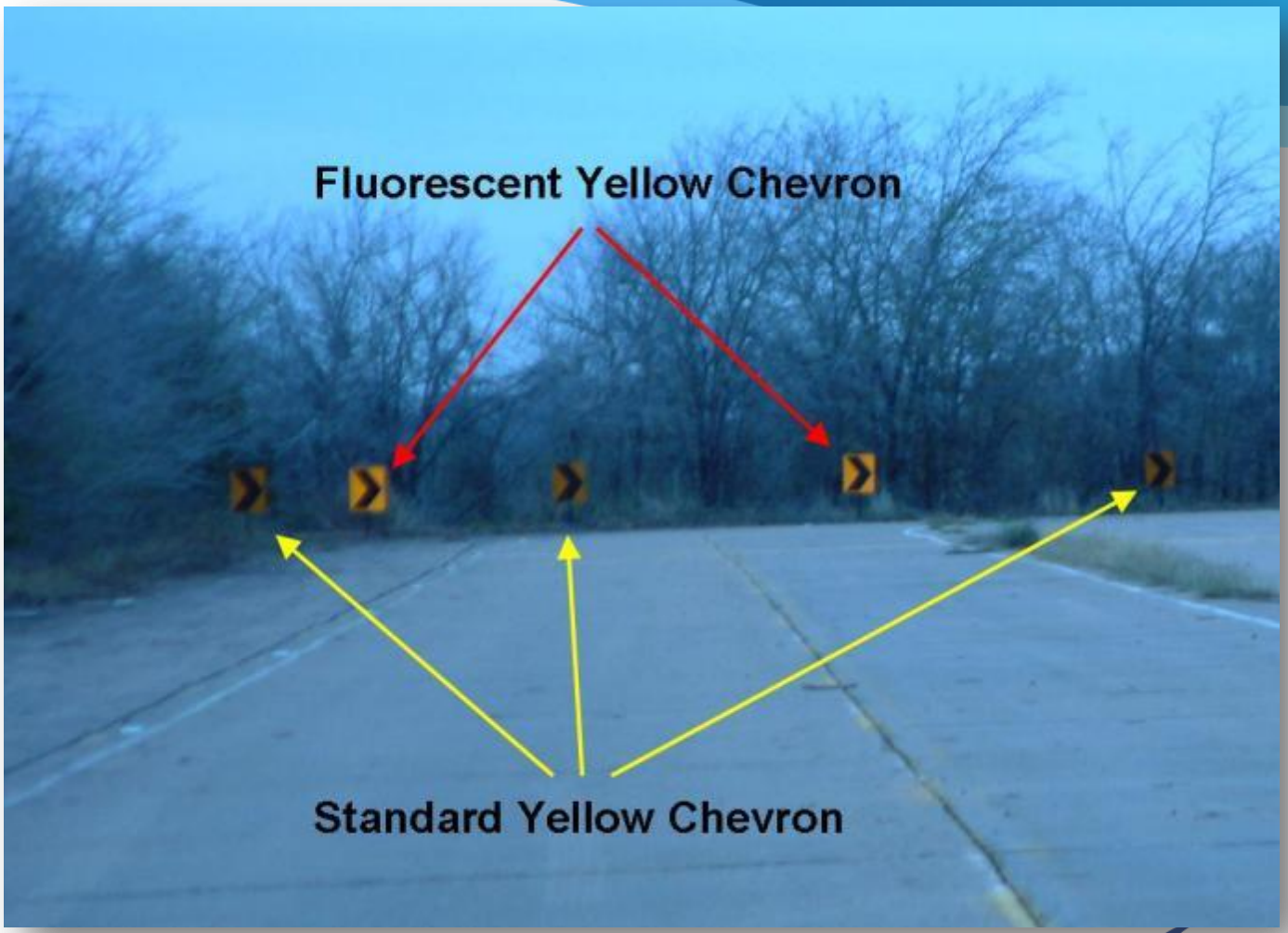
Few cues remain

Task more difficult

Bad Signs are Out There

Some agencies need better sign maintenance guidance

High Grade Sheeting



Orient Chevron to Traffic Approach

Sign Maintenance

Daytime:

Nighttime:

Post Delineation

Sign Visibility

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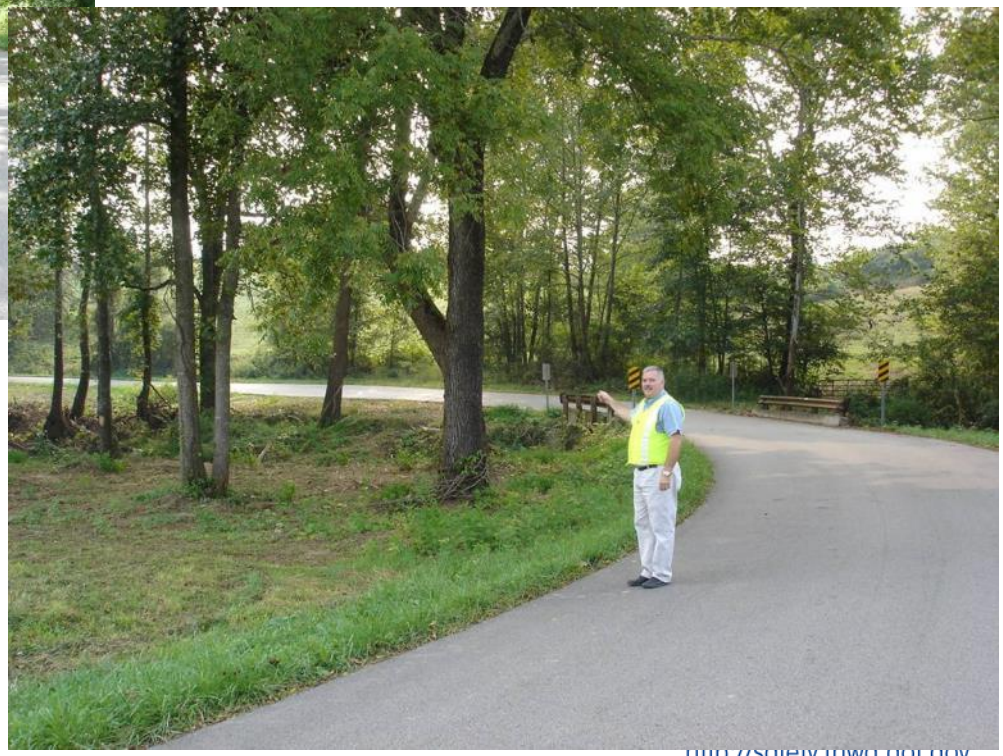
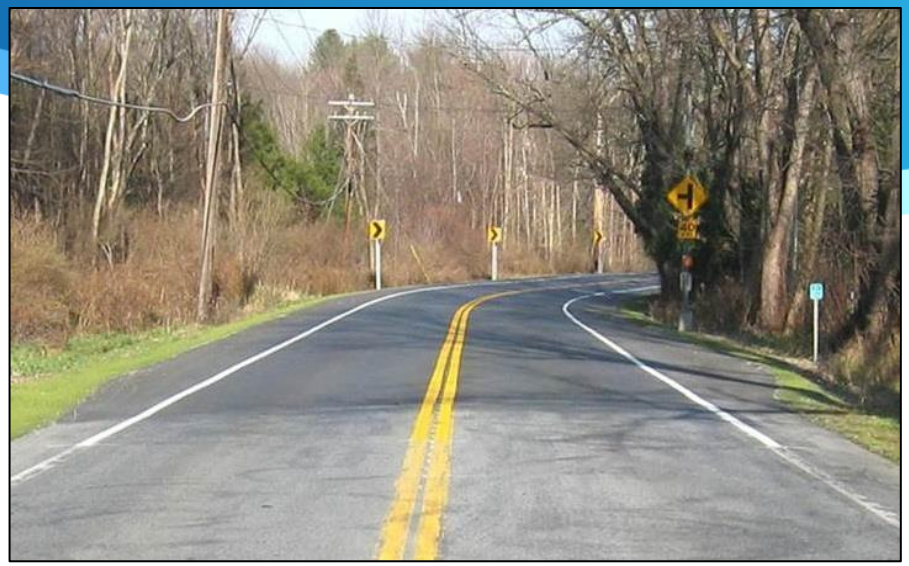
Preview Distance



Shoulder Improvement

Shoulder Widening

- widening the shoulders or providing a shoulder where one previously did not exist, provide more recovery area to regain control during roadway departure.
- If space is only available to one side, widening the outside shoulder will most likely provide the greater benefit.



Widening on the inside and outside of the curve.

Shoulder Paving

- Provide increased capacity for recovery if they leave the travel lanes.
- Paving shoulders can also be accompanied by Safety EdgeSM and rumble strips.

Shoulder paving operation.

Safety EdgeSM

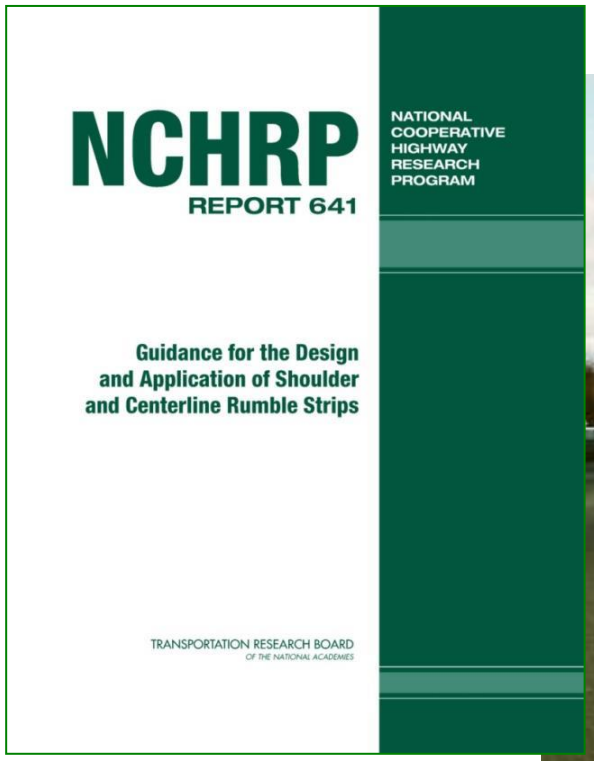
- Safety EdgeSM is a paving technique used system-wide to improve pavement durability and reduce crashes
- it shapes and consolidates the pavement edge into a 30-degree wedge
- Allows controlled recovery for drivers after straying due to inattention.
- The added durability of the edge reduces the tendency of the pavement to ravel.
- Reduce total crashes by approximately 6 percent on t lane roads (Graham et al., 2011).

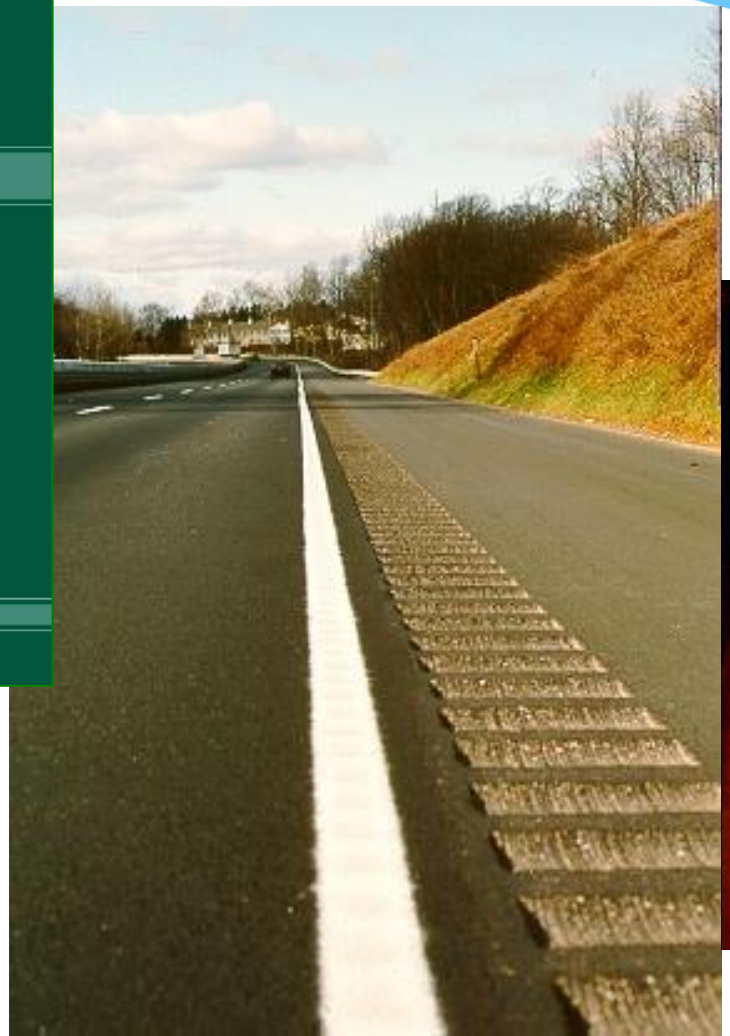
Pavement with and without the Safety Edge[SM].

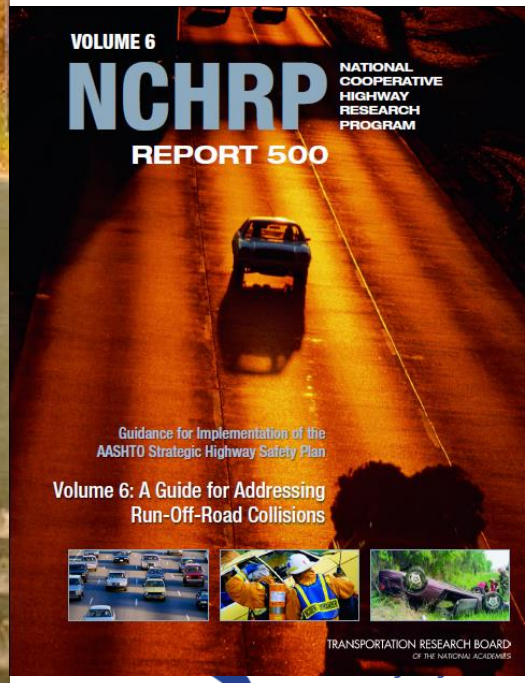
Backfilling against newly installed Safety Edge[SM].

Keeping Vehicles on the Roadway

Rumbles







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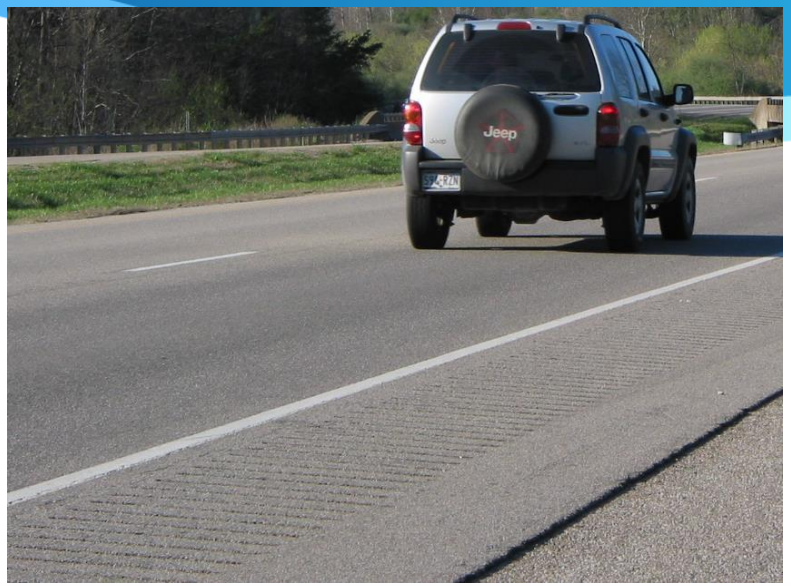
Installing Rumbles to Keep Vehicles on the Roadway

- Rumble Strips primarily address crashes when roadway departure is a result of a **Distracted or Drowsy Driver**
- On roads with snow cover on the markings, rumble strips can help driver with **proper lane placement**
- **Can be rolled, milled or raised.**



Rumble Placement

- Shoulder-Typical lengths of 12” to 16”

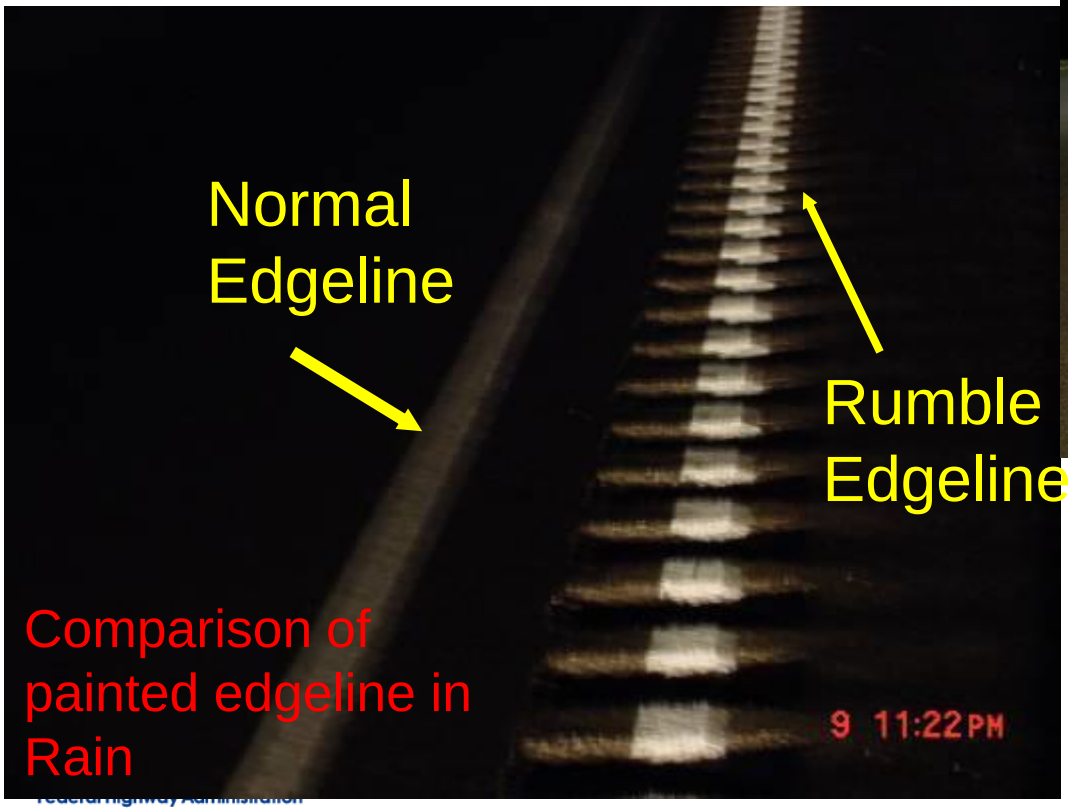
- Edge Line / Rumble Stripe-Typical lengths of 8” to 12”.

- Centerline

Rumble StripEs

Enhanced Visibility

Michigan initiative with edge line painted over shoulder rumble strip.



Enhanced Durability

Michigan initiative with edge line painted over shoulder rumble strip.

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Centerline Rumble Strips

Centerline rumble strips milled across markings / joint

Centerline rumble strips on either side of pavement markings (least common)

Centerline rumble strips

Variable spacing

Placement

Combining Shoulder and Centerline Rumbles

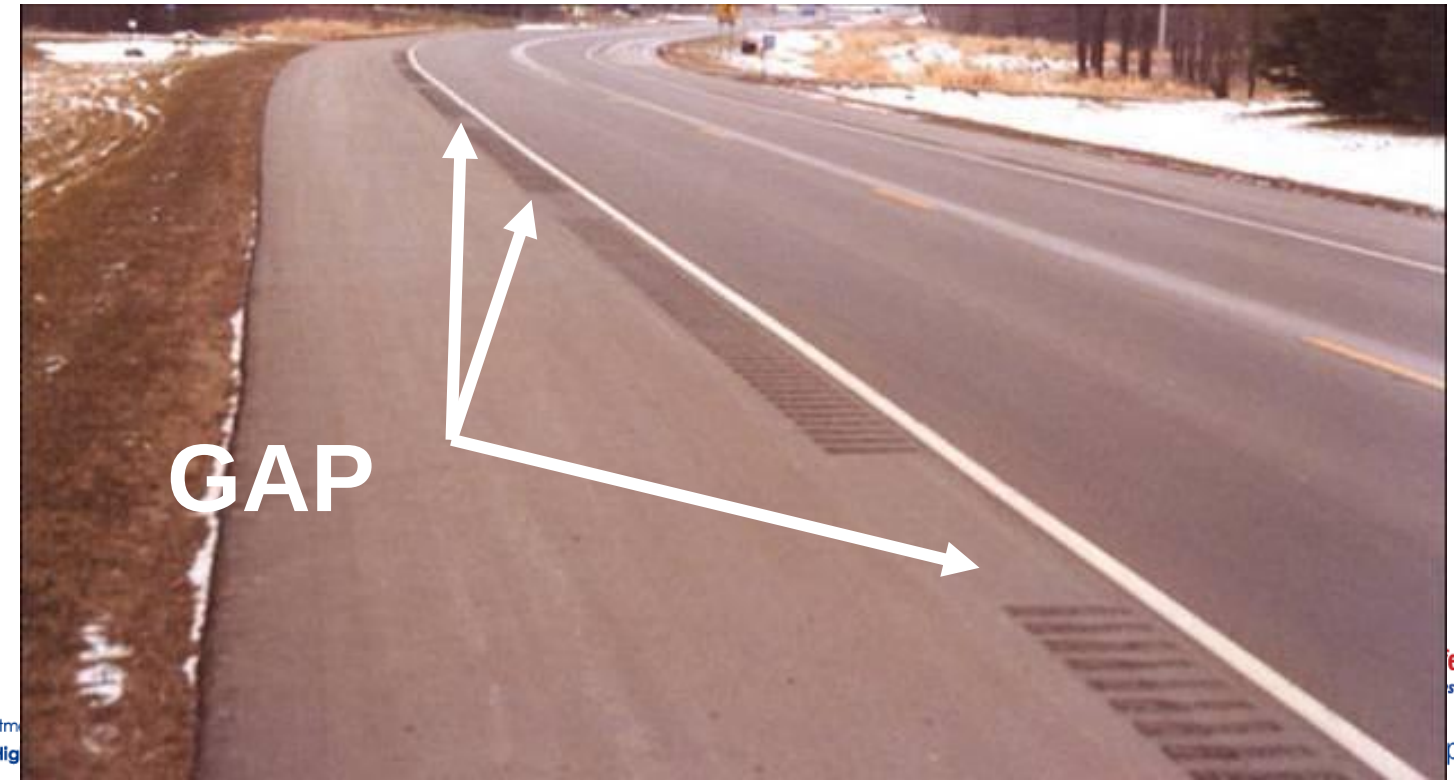
Bicycle Friendly Shoulder Rumble Strip and Centerline Rumble Stripe Washington

Rumble Implementation Issues

- Bicycle
- Motorcycle
- Pavement Thickness/Type/Condition
- Noise

Bicycle Issues

- Gaps can allow bicyclist to move between lane and shoulder without traversing the rumble
- Shallower rumbles (3/8” versus 5/8”) may be an acceptable compromise



Centerline Rumble Strips & Motorcyclists

Minnesota DOT Study:

"Effects of Centerline Rumble Strips on Motorcycles"

- Zero of 9845 motorcycle crash reports mentioned rumble strips as a factor
- 44 hours of observation showed:
  - Small number of rumble strip crossings
  - No instances of directional changes or unusual riding behavior during crossing.
  - Rumble strips did not seem to inhibit any passing opportunities.
- Closed-course examination showed no steering, braking or throttle adjustments during strip crossing.
  - Post-ride interviews confirmed these observations
  - No rider expressed difficulty or concern with crossing rumble strips.

Conclusion - no indication that centerline rumble strips pose a hazard to cyclists

Noise Issues

- Some complaints have been made by nearby residents
- NCHRP Report 641 provides references to tools to predict noise levels.
- May want to discontinue in some areas where there are a lot of residences

Basics of Roadside Design

Roadside Design First Priority: Remove all hazards!

Remove hazards: Some starting points are more difficult than others…

Roadside Improvements

- Clear Zone
- Slope Flattening
- Roadside Barriers
- Delineation on Barriers

Typical barnroof slope design. Source: Alaska DOT.

Retroreflective panels in the web of a W-beam. Source: Michigan DOT.

Photo. Delineators held in place with post bolts and installed on post.

When is Delineation Too Bright?

Slope Flattening

- Slope Flattening
  - the steepness of the sideslope is a critical factor in their ability to keep the vehicle stable, regain control of the vehicle, and avoid obstacles.
  - The AASHTO Roadside Design Guide considers foreslopes that are 1V:4H or flatter to be traversable and recoverable
  - Slopes that are between 1V:3H and 1V:4H, traversable but non-recoverable,
  - Slopes steeper than 1V:3H, critical slopes, the risk of the vehicle overturning is increased.
  - CMFs include flattening side slopes have shown a range of expected crash reductions of 22 to 42 percent for injury crashes and 24 to 29 percent for PDO crashes

Discussion of SC's Roadway Departure efforts

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Tree Removal Program

- Tree crashes - 50% of fatal and serious injury crashes.
- Colleton County I-95 Timber Harvest Project.
- Partnership with SC Forestry Commission to remove trees:
  - Enhanced forest health,
  - Improve highway safety,
  - enhance aesthetics.

SC Forestry Commission

- Estimated amount of clearing (including type of wood and quantity to be removed)
- Marked trees to be retained
- Provided guidance on specifications for Contract
- Educated SCDOT personnel and Contractor on South Carolina Forestry Commission Best Management Practices
- Reviewed project area after substantial completion

Silviculture

- Clearcutting Method
  - Completely removes mature stand of trees
- Shelterwood Method
  - Involves removal of most of the mature stand
- Seed Tree Method
  - Similar to shelterwood, but leaves only a few residual trees (20 per acre)

Site condition at median before and after clearing

Opportunity Trees vs. Forests

Reality is in between

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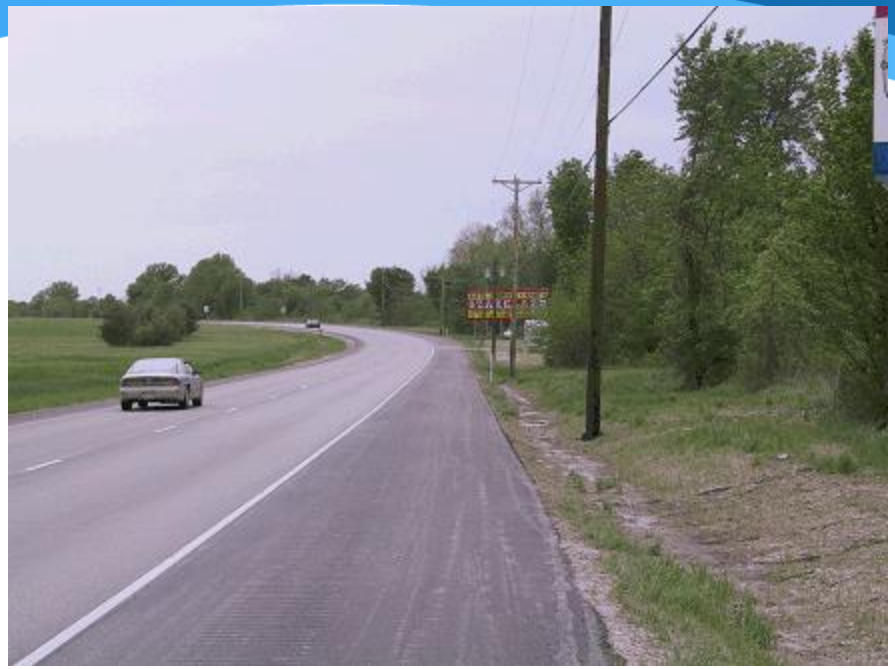
Tree Removal

- **Step 1: Keep Drivers on Road**
  - Apply sign and marking upgrades consistent with the MUTCD
  - Consider centerline and edgeline rumble strips
- **Step 2: Provide Safe Recovery**
  - Correction of any 2-inch+ shoulder drop-offs
- Consider removal
  - Evaluate clear zone to determine if other fixed objects also need treated.
- Identify environmental issues
- Identify local issues (historical significance, etc.)
- State ROW vs. Private Property

Utility Pole Relocation and Delineation

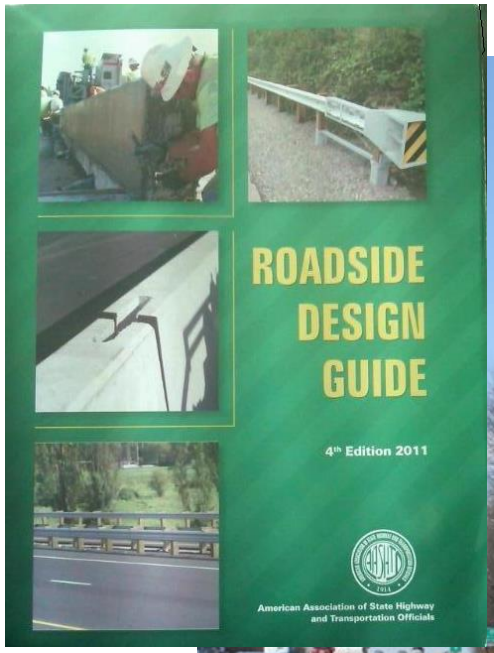


Utility Poles Relocated or Removed

Utility Pole Delineation

Basics of Roadside Design

- Second Priority: Redesign the feature



BREAKAWAY SIGN SUPPORT

Basics of Roadside Design

- Redesign the feature: Breakaway supports

Basics of Roadside Design

- Redesign the feature: Culvert ends match slope

Basics of Roadside Design

- Shield the feature

Guardrail Terminals – End Treatment

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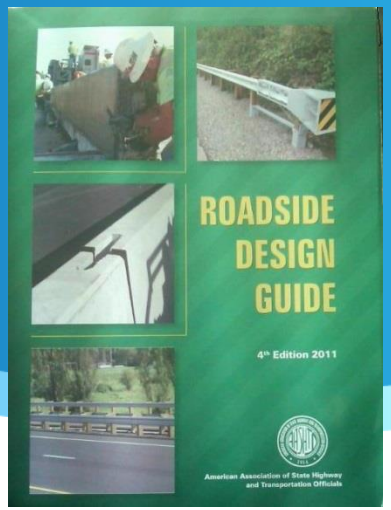
Breakaway Hardware



- Sign Supports – Mandatory within clear zone of all roads open to public travel
- Luminaire Supports – Required on NHS since 1990
- Traffic Signal Poles – Generally not on breakaway supports
- Timber Utility Poles – 2nd most common fixed object involved in fatal crashes
- Mailboxes – unique set of problems

SIMULATED STONE MAILBOX SUPPORT

Traffic Calming/Speed Management

Traffic Calming on Main Roads Through Rural Communities
http://www.tfhrc.gov/safety/pubs/08067/index.htm

Peripheral Transverse Pavement Marking

ADDRESSING INTERSECTIONS IN CURVES

NCHRP Report 600 Human Factors Guidelines for Road Systems points out that the demands on drivers approaching and navigating horizontal curves include

- ***visual demands,***
- ***vehicle control demands,***
- ***and speed selection.***

The presence of intersection at horizontal curve often limits the available sight distance for safe maneuvering and the physical constraints of the intersecting roadway often limit the application of signing and other delineation.

Dotted edge line extensions at an intersection within a curve.

Additional Findings

A study by Indiana DOT found that curvature was a significant factor in the relative safety of intersections where the major road is a four-lane divided highway and that full curvature and superelevation increased crashes by 30 percent in comparison to tangent intersections (Savolainen and Tarko, 2004).

Sight distance is limited due to the intersection being inside the curve.

Delineation Treatments

Adjusting Signs and Markings for the Intersecting Roadway

- Center line and edge line markings are typically not continued through the intersection.
- The MUTCD allows dotted edge line extensions through intersections along the mainline.
- Adjustment of the location of the remaining chevrons or delineators may be appropriate to delineate the maximum curve length.
- Advance warning signs

Delineation Treatments (continued)

Smooth Lane Narrowing

- the treatment narrows the lane width approaching the intersection with a combination of markings and rumble strips.
- The combination of rumble strips and markings to narrow the lanes reduces operating speeds on the intersection approaches.
- reduce all crashes by 32 percent and fatal and injury crashes by 34 percent.
- 85th percentile speeds were reduced by roughly 5 mph.

Pavement markings narrow the travel lane as the driver approaches the intersection.

Addressing Visibility Issues

Visual Traps – occurs when the road curves, but visual cues such as breaks in the tree line or the continuation of power poles lead a driver to think the road continues straight.

- additional emphasis needed to warn the driver and delineate the curve through the use of delineators, chevrons, or pavement marking signs
- Avanced markings within the lane may be appropriate.

An example of a visual trap exists when a crest vertical curve blocks the view of the upcoming horizontal curve (top photo). What appears to be a continuation of the road in the distance is actually an intersecting roadway in the midst of a curve (bottom photo).

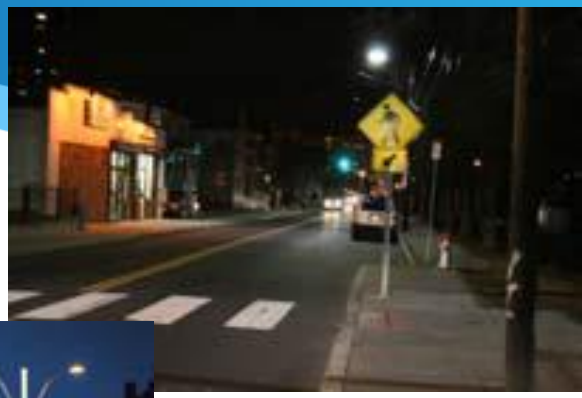
Addressing Visibility Issue (continued)

Intersection Conflict Warning Systems (ICWS)

- can be designed to either detect vehicles on the minor road and indicate their presence to drivers on the main road, or indicate to the driver on the minor road when there is oncoming traffic on the mainline.

Lighting

- The presence of lighting has been shown in improve safety at intersections. The INDOT study of intersections with curvature found that crashes tended to be overrepresented during nighttime conditions (Savolainen and Tarko, 2004).
- The CMF Clearinghouse indicates the presence of intersection lighting is associated with an 11.9-percent reduction in total nighttime crashes. The presence of fixed illumination is associated with a 3.2-percent increase in total daytime crashes



Intersection Sight Triangles

Problem:

- The intersection on the inside of the curve, is often restricted by the geometry to view oncoming traffic,
- When the intersection is not near the center of the curve, sight triangles may cut across the curve and require significantly more clearing.
- Need slopes flattening to provide the adequate minimum intersection sight distance.
- The use of and location of guardrails on grades could interrupt the sight lines for intersections in and near curves.

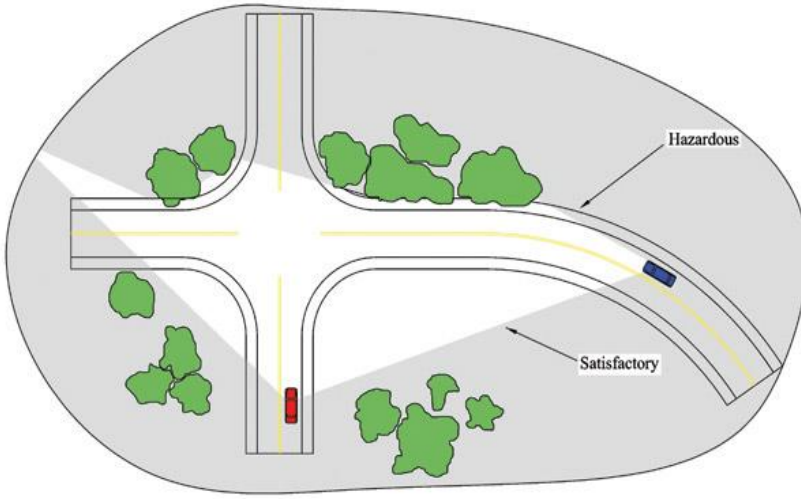
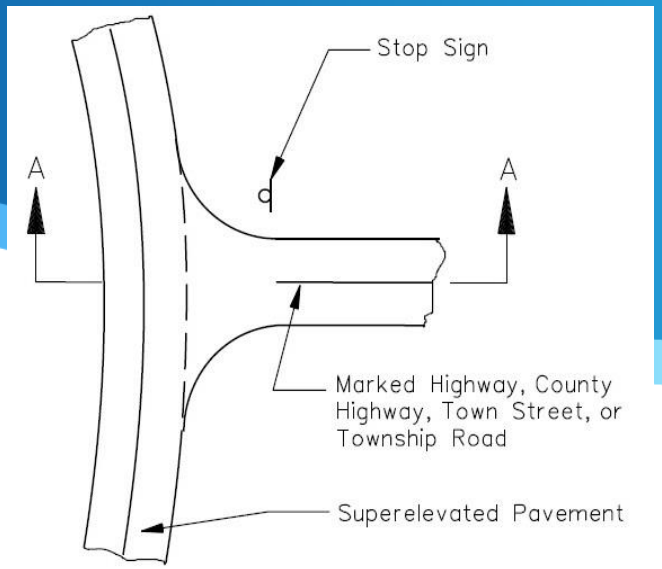


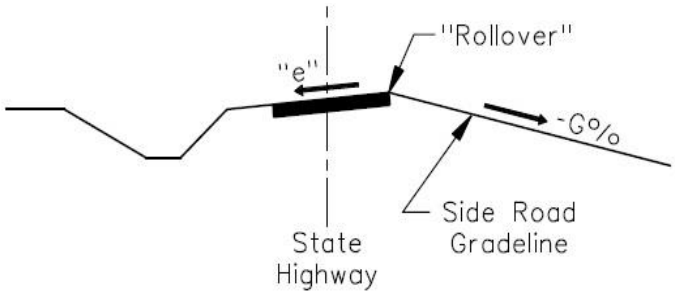
Figure 63. Illustration. Limiting the growth of vegetation is important to maintain appropriate sight triangles.

Solution

- Re-configure the intersection to achieve the desirable sight distance- adjust superelevation
- An “All-Way” stop-controlled intersection may be appropriate at times.
- Speeds and traffic volumes must be considered when planning to change the intersection to an “All-Way STOP.”
- A small roundabout should also be considered for this type of control.



PLAN VIEW



CROSS SECTION A-A

Type of Improvement Category	Maximum Superelevation Rate “e” for Intersections on Curve	Rollover Guidelines
“New Construction” at an important crossroad	4% Desirable Maximum	5% Desirable Maximum 6% Maximum
To remain in place with “Reconstruction” at an important crossroad	6% Maximum	7% Desirable Maximum 8% Maximum
To remain in place with “Reconstruction” at a minor crossroad	8% Maximum	9% Desirable Maximum 10% Maximum

Pavement Improvements and Intersection Alignment

- Improve Friction
- Adjust Superelevation for an Intersecting Roadway
- Pave Intersection Approach on Gravel Roads

Intersection with paved approach.

Intersection with aggregate scattered on paved roadway.

- Add Turn Lanes
- Roundabouts

Overview of the Systemic Approach to Safety

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What we mean by “systemic safety

An improvement that is widely implemented based on high-risk roadway features that are correlated with particular severe crash types.

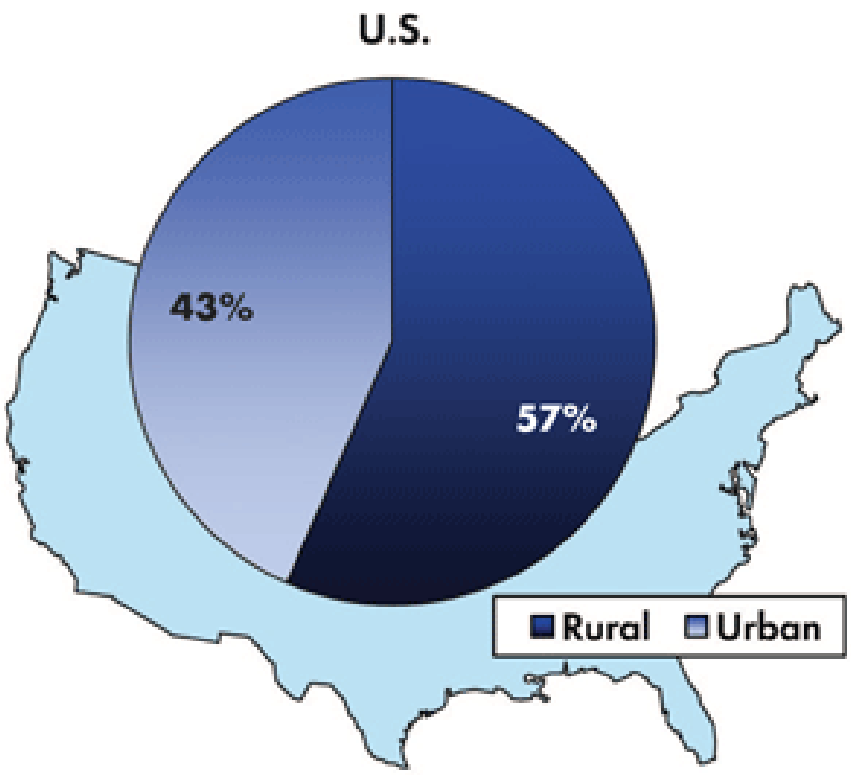
Acknowledges crashes alone are not always sufficient to establish prioritization.

Definitions

- **Systemic** – Deploying countermeasures at locations with the *greatest* risk
- **Systematic** – Deploying countermeasures at *ALL* locations

The Challenge

- Is there really a problem? (57% of fatal crashes on rural roads)
- What am I doing wrong? (Change can be difficult)
- Public/Political resistance (Signals solve everything)



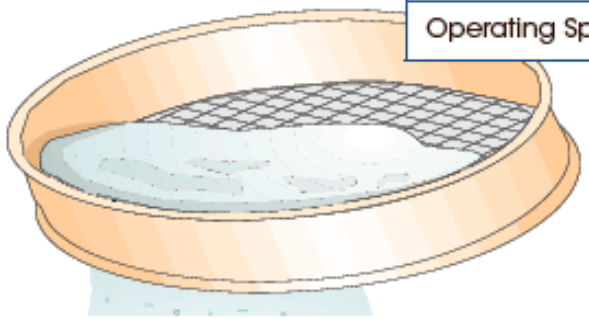
Systemic Analysis

- Implements a **system-wide screening** of a roadway network based on the presence of ***high-risk roadway features*** correlated with particular severe crash types,

Road Features
Shoulder Width/Type
Horizontal Curvature
Access Density
Roadside Rating
Intersection Skew

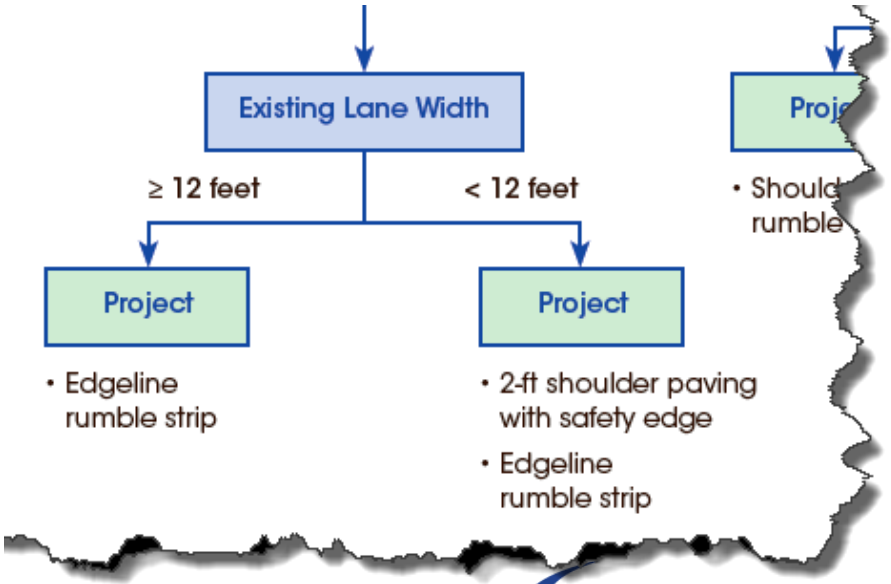
Traffic Volume
Average Daily Traffic (ADT)

Other Features
Presence of Commercial Development
Proximity to Rail Crossing
Distance from Previous Stop
Operating Speed



Systemic Analysis

- Examine the system as a whole
- Identify roadway elements with high crash experience that would be corrected on a system-wide basis
- Supplements traditional site analysis to form a comprehensive method for safety planning and implementation



Source: FHWA Systematic Safety Project Selection Tool

Systemic Analysis

- Particularly applicable when a significant number of severe crashes happen over a wide area:
  - Rural Roadways
  - Local Roadways
  - Specific Crash Types
    - (e.g. cross-median,

- May include treating locations that haven't experienced many crashes

A systemic illustration…

- You could select High-Friction Surface Treatment locations on fatal crash data alone…

but considering other roadway characteristics would likely lead to a better risk-based solution.

Photo Source: CH2M HILL

- Curve Radius
- Traffic Volume
- Wet-weather crashes
- Friction Data

A systemic illustration…

- You could select cable median barrier locations on fatal crash data alone…

but considering other roadway characteristics would likely lead to a better risk-based solution.

Photo Source: Iowa DOT

Systemic analysis

- Is not simply a blanket or policy approach (applying a low-cost countermeasure everywhere).
- Requires data analysis to identify higher risk roadway characteristics.
- Deployment is then targeted to where those higher risk features are located.

Illinois cable median barrier

median width

traffic volume

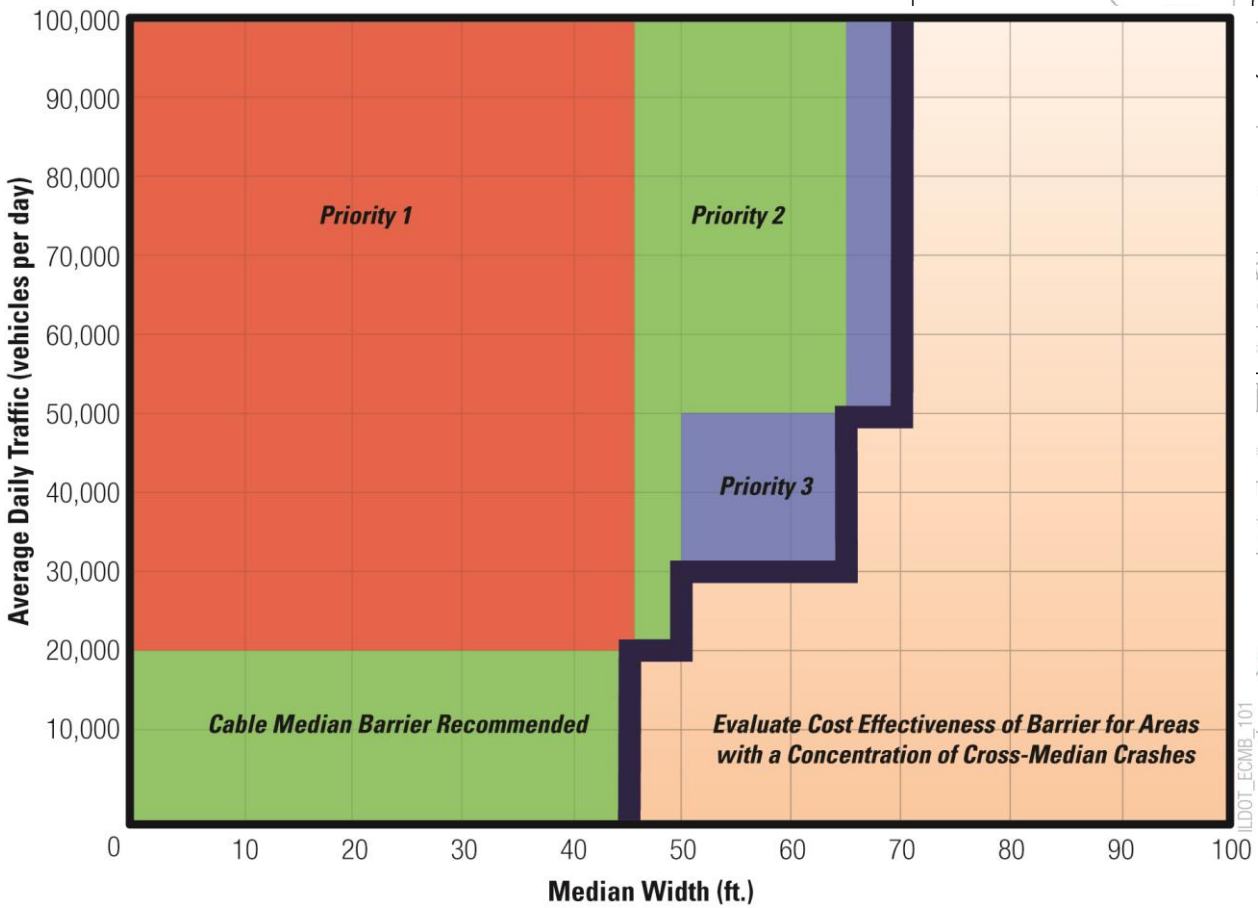
Other possible risk factors

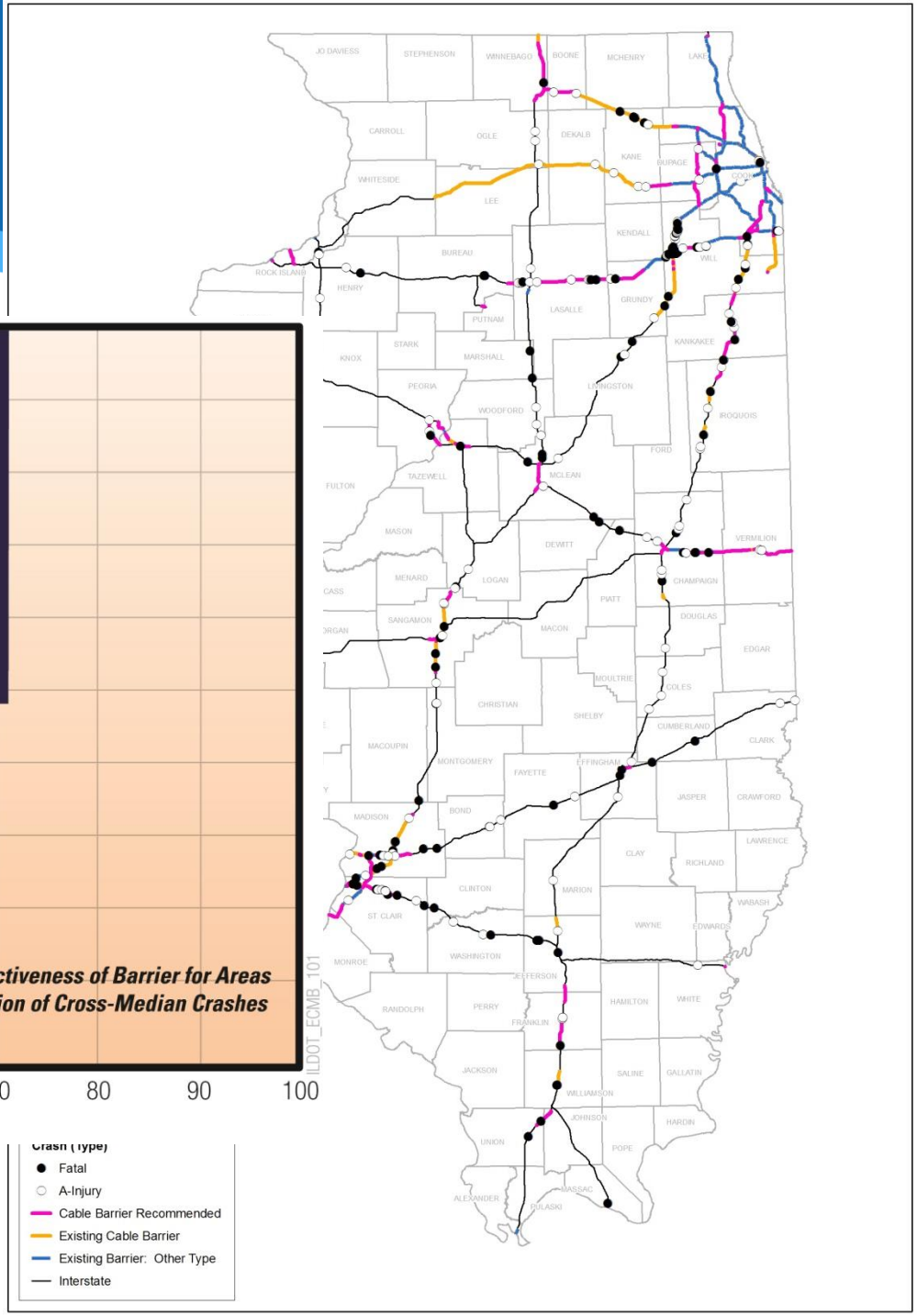
horizontal alignment

interchange location/spacing

weather/climate

Illinois – cable median barrier





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Roadway Departure Resources

- **FHWA Rumble Strip/Stripes Web Page**

http://safety.fhwa.dot.gov/roadway_dept/pavement/rumble_strips/

- **FHWA Roadway Departure safety web page**

http://safety.fhwa.dot.gov/roadway_dept/

- **FHWA Roadside Hardware Policy and Guidance Web Page**

http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/

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Systemic Safety Resources

- **Systemic Approach to Safety Website**

  http://safety.fhwa.dot.gov/systemic